PS/PL/Min. 93-44
5/07/93

SUMMARY NOTES OF THE CLIC/PS MEETING ON 2 JULY 1993

1. FIRST RESULTS OF ANALYSING THE SPATIAL ENERGY DISTRIBUTION IN THE LASER BEAM WITH A CCD CAMERA

P. Joly

Fig. 1: the hardware layout.

To interpret the raw data, the background is subtracted and the display reconstructed with five intensity levels. The center of gravity is computed as well.

An easy and convincing spatial calibration is obtained by putting a 1 mm Ø piano string in the beam.

The distribution shown of the 262 nm beam reveals an uneven distribution and a change from pulse to pulse.

Different wavelengths should be measured as soon as the laser system is believed to be in a good shape.

The present field of detection - the camera - is 4 by 6 mm. For larger beam diameters either a lens or a screen viewed by the camera can be used.

A study on the compatibility of the software with other versions should be made.

Comment. For trying the CLIC BPM's the charge centre of the e^- bunch should not jitter with more than one micron from pulse to pulse. The full beam may not give this. Can an appropriate diaphragm bring an improvement?

The idea of using a thermionic gun and buncher was voiced again.

2. CHOICE OF LASER PULSE TRAIN GENERATOR - PTG - AT 262 NM

2.1 The specification for the PTG

J.P. Delahaye

See app. 1.

Using two laser pulses separated by 4 ns and by splitting each pulse in 12 pulses at 333.5 ps one creates in the CAS structure a constant field over 4 ns (see fig. 2 and 3).

Estimated that with 70 10^{-6} J per laser pulse and a train of 24 pulses we get 3 nC per bunch providing 63 MW at the TRS output.

The phase error of the bunches in TRS effects the power generated. Fig. 4 shows that the error should remain less than 2 ps.

2.2 Which type of PTG ?

We have used two types :

- intensity splitters with ' zero ' degrees mirrors (dec.'92)
- polarization splitting with '45°' plates (last run)

Both types enabled us to generate MW's at 30 GHz. The relative merits have been analysed. Both can be made to work.

KK. Geissler proposes a mixed system. Start with a polarization splitting to generate 4 pulses on one line and then add 0° splitting.

Fig. 5: the principle to get 2 or 4 pulses on one output line.
Fig. 6 and 7: the mixed system.

Based on this proposal, KK. Geissler and S. Schreiber will construct a PTG delivering a train of 24 pulses leaving the generator on three lines (bottom fig. 7). Aim: have the PTG and its monitoring ready end Oct. 93

3. Comments on the results of the last CTF run

H. Braun

A note on the last run will soon be distributed. The following is limited to the beam performances.

Single bunch

For a small laser spot size on the pc the max. charge is produced at phases with a high E-field. Fig. 8 shows the comparison with the PARMELA simulations.

With enlarged spot size the agreement with PARMELA results is better (see fig. 9).

The charge from the gun doesn't increase linearly with the laser energy on the pc (see fig. 10).
Note the saturation at UMA455. The max. charge that passed TRS in a single bunch is about 5 nC. Simulations are under way to examine this limitation.

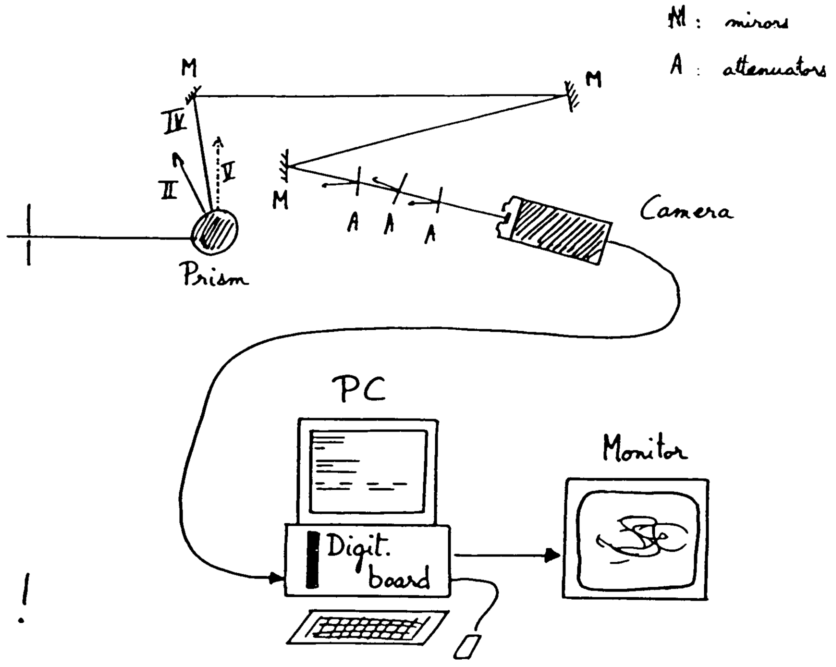
Pulse train

The train is much more efficient. Here as well the transmission through TRS goes down with charge but the saturation is not yet reached (Fig. 11).

The position of the bunches in the two times 8 bunch train in front of the TRS is measured with the TCM445 (Fig. 12). The position variations in the second train may be generated by the first train in LAS. In fact the 2nd train passes TRS less well.

The 'double train' gives a boost in the 30 GHz power generation (Fig. 13: 9.2 MW). This measured power is compared with the expected one and the resulting value for the form factor F is 0.90! The e^- bunch length depends on the distribution (Fig. 14) but is much shorter than the measured one. So, what is wrong?

(Total attenuation : more than 10 000 times)



Digitizing and storage on PC hard disk
(256 Kbytes per image)

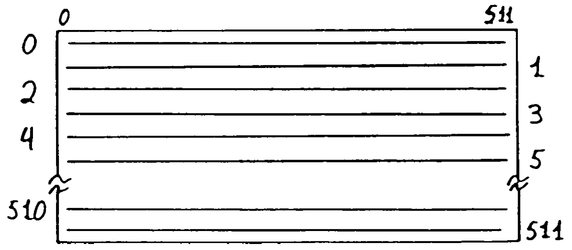
of a series of 16 images (1 every few seconds)

512 × 512 pixels
256 graylevels (8 bits)

THE VIDEO SIGNAL
IS INTERLACED !

1 image = 2 frames
(1/25 s) (1/50 s)

even frame : lines 0, 2, ..., 510
odd frame : lines 1, 3, ..., 511



spot + background
background

Fig 1

APPENDIX 1

Specification for a Pulse Train Generator (PTG) adapted to a 262 nm Wavelength Operation on the CTF Photocathode

Mandatory:

- **Number of pulses in the train by laser pulse:** 8, easily extendible to 16 (and 12 if possible)
- **Time interval between pulses i and j on the photocathode:**

  (j - i) x 333.5 psec ± 2 psec
- **Variation of laser energy between pulses in the train:** ≤ ± 10%
- **PTG energy transmission efficiency:** ≥ 50%, similar longitudinal and transverse energy distribution
- **Adjustment of the beam diameter on the photocathode** between 1 and 10 mm with similar transverse profiles and maximum misalignment ≤ ± 0.5 mm between individual pulses in the train.
- **On line monitoring and instrumentation** downstream of PTG, if possible independently of CTF operation, for tuning and checking the absolute energy, the longitudinal and transverse profile, the alignment of the individual pulses as well as the delays between pulses The monitoring system, including the optical path to the streak camera, should preferably be located close to the PTG on the present laser bench.
- **Tuning of the energy distribution, timing and alignment** based on a written procedure if possible independently of the electron beam.
- **Long term stability** (no retuning before at least ≥ 8 hours) of the energy distribution, the tuning, alignment and transverse profiles of the individual pulses
- Possible **by-pass** of the PTG

If possible:

- **A single optics path** from the PTG to the photocathode for simplified optics and ease of instrumentation, monitoring and tuning
- **Free choice of an ensemble of pulses** in the train

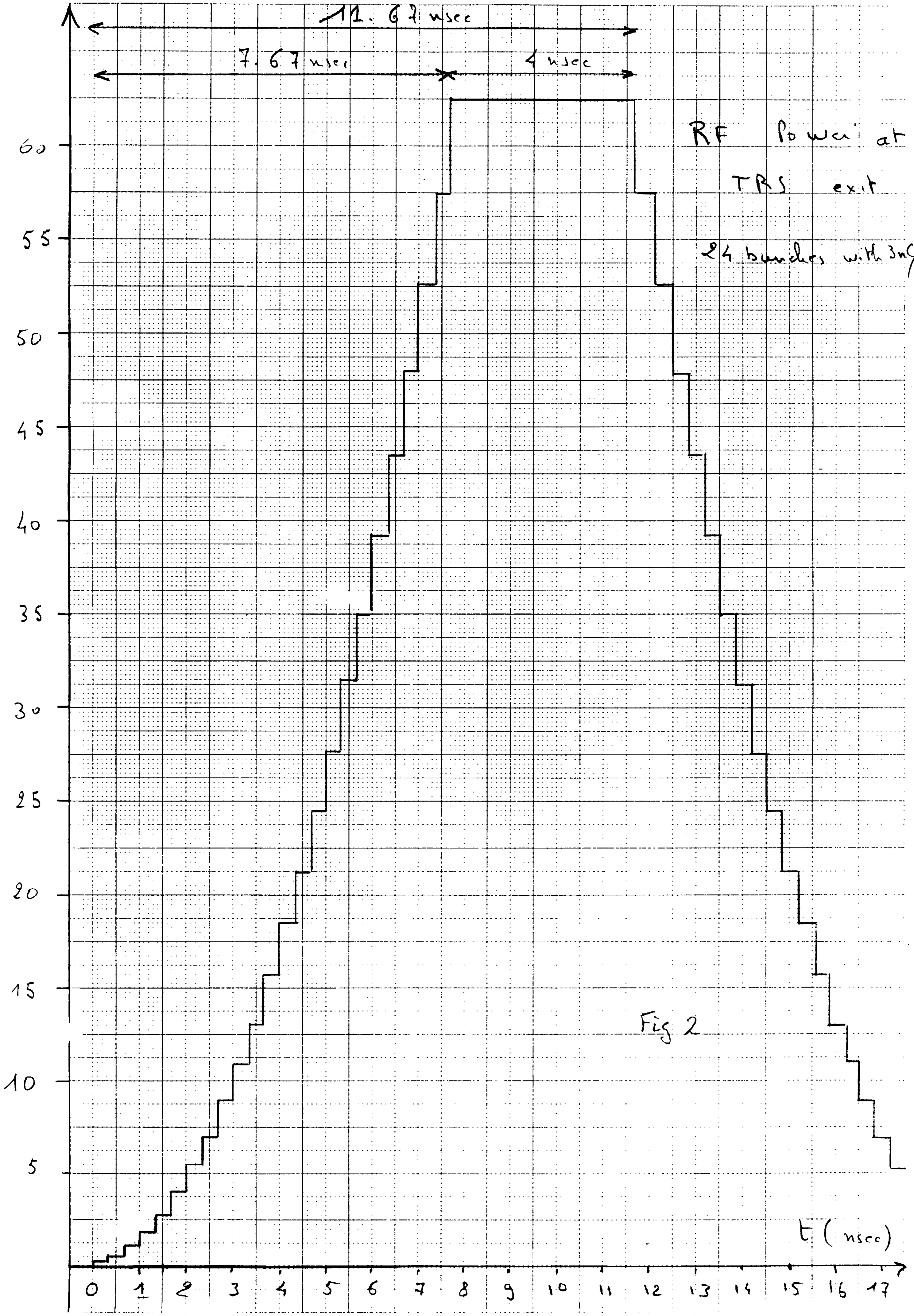
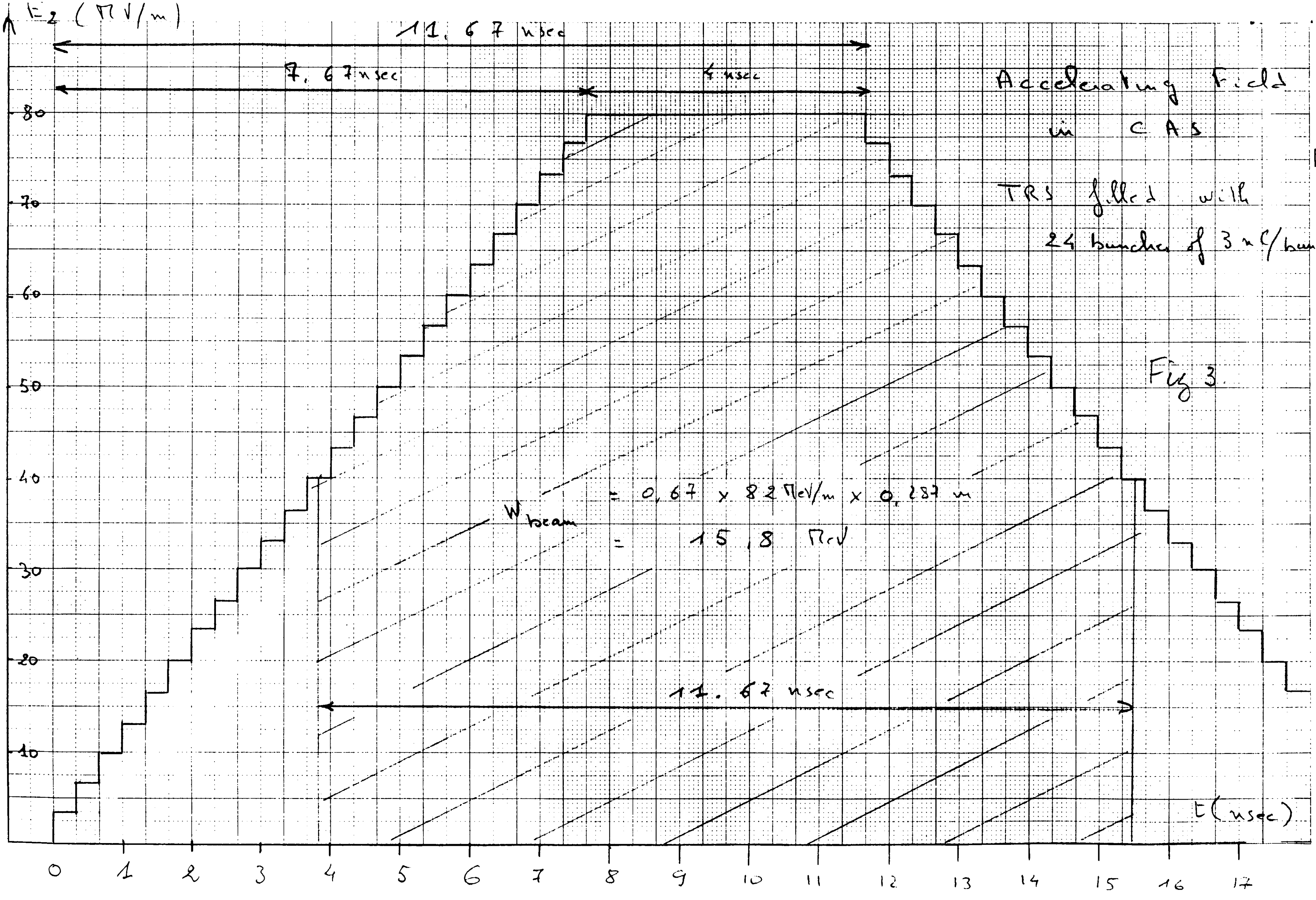

11.67 nsec
7.67 nsec
4 nsec
RF Power at TRS exit
24 bunches with 3nC/b
60
55
50
45
40
35
30
25
20
15
10
5
t (nsec)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

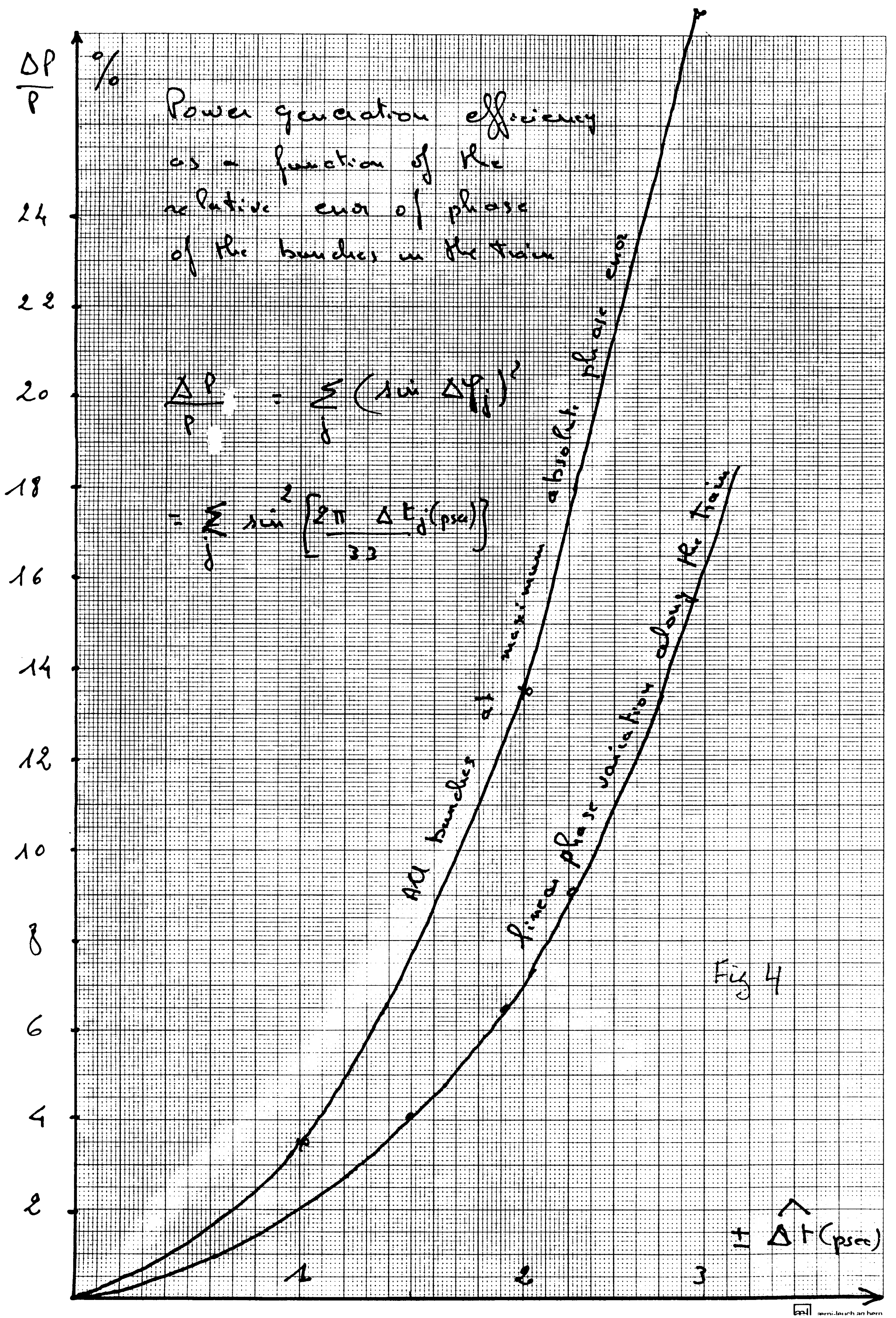
Fig 2



Accelerating Field in CAS

TRS filled with 24 bunches of 3 nC/bunch

Fig 3



Power generation efficiency as a function of the relative error of phase of the bunches in the train

$$\frac{\Delta P}{P} = \sum_j \left(\sin \Delta\varphi_j\right)^2$$

$$= \sum_j \sin^2 \left[\frac{2\pi}{33} \Delta t_j(\text{psec})\right]$$

Fig 4

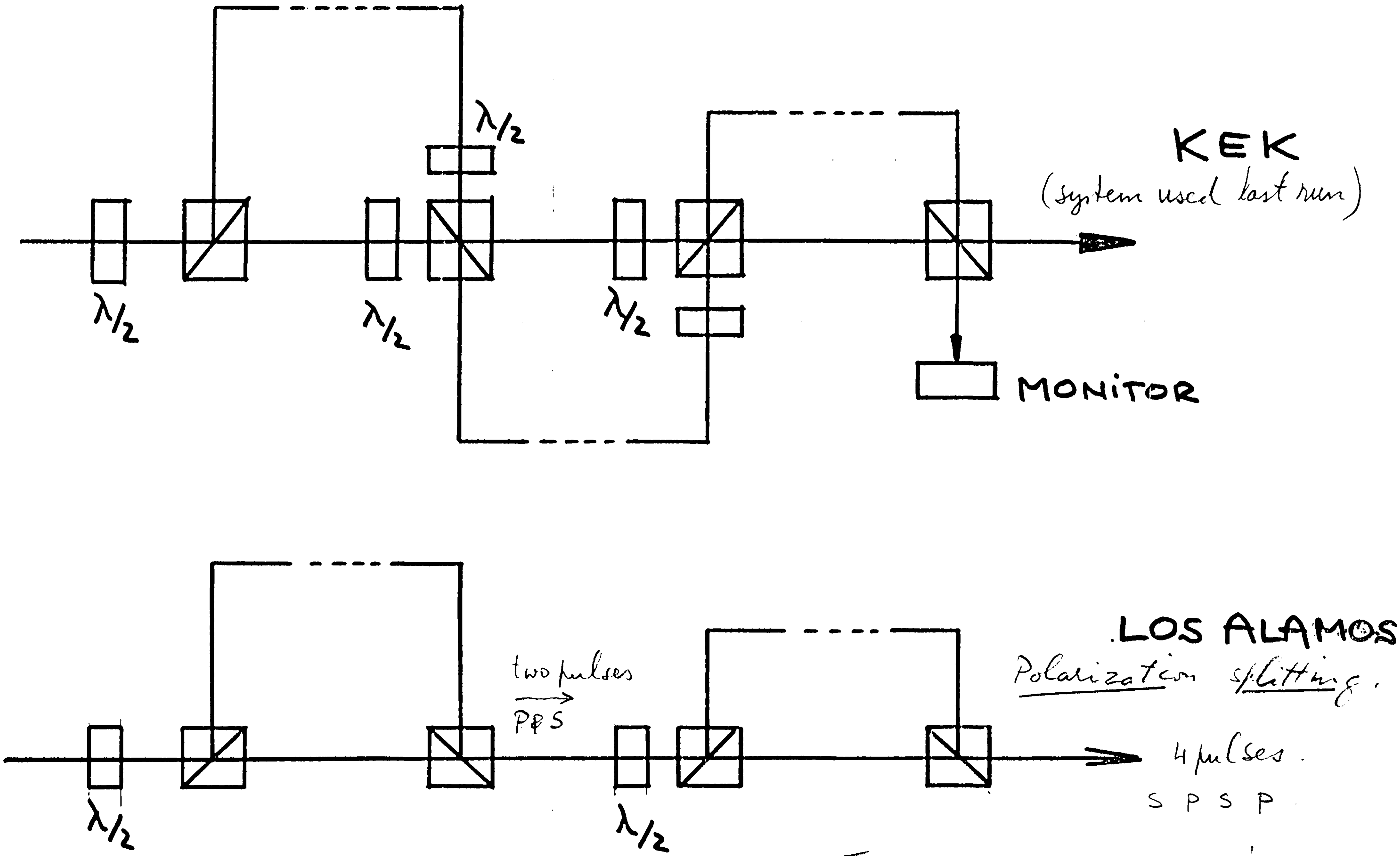
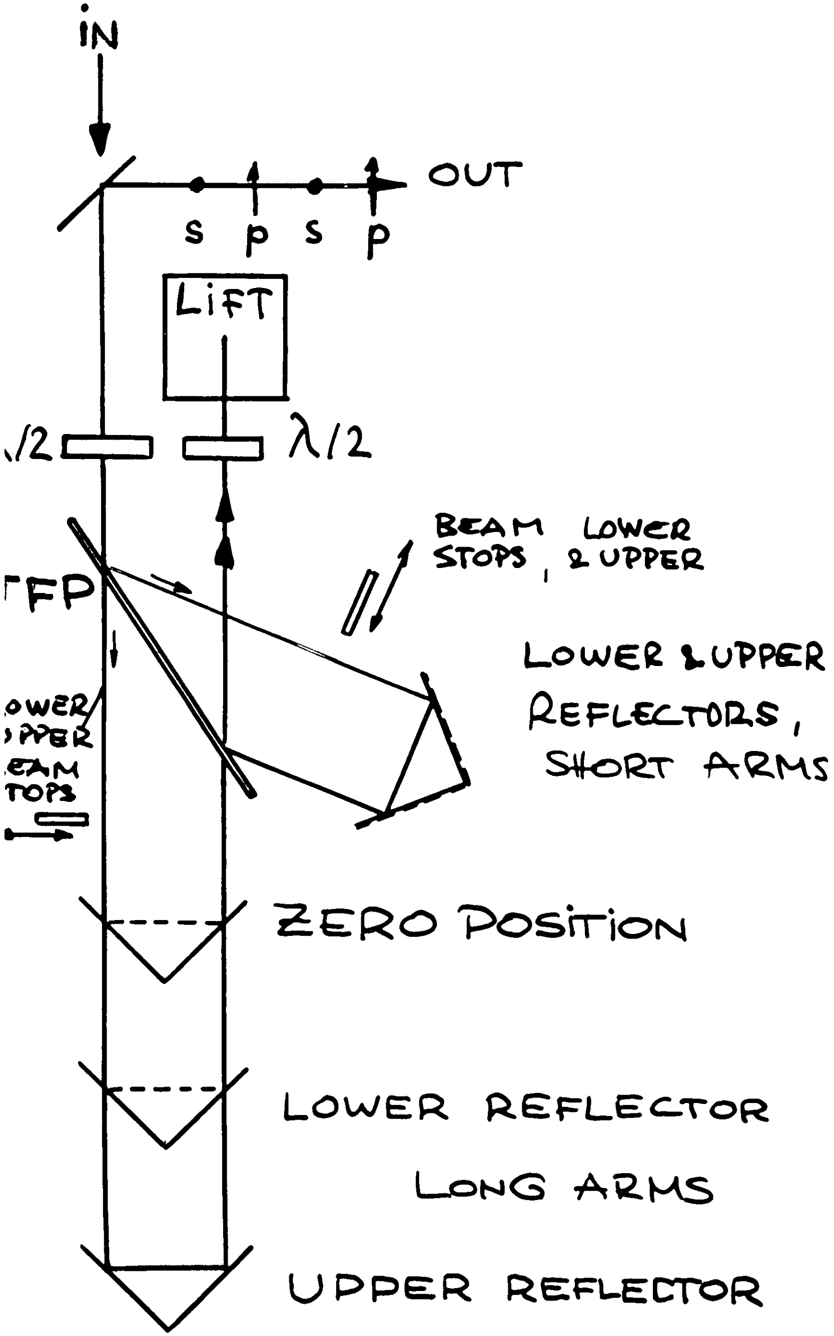

KEK
(system used last run)
λ/2
λ/2
λ/2
λ/2
MONITOR
LOS ALAMOS
Polarization splitting.
two pulses
P&S
4 pulses.
S P S P
λ/2
λ/2

Fig 5

6.07.93



Selecting pulse ensembles

PULSES	UL	LL	US	LS	A	B	C
1	x	x			x		x
2	x			x	x		x
3		x	x		x		x
4			x	x	x		x
1,2	x				x		x
1,3		x			x		x
2,4				x	x		x
3,4			x		x		x
1,5	x	x					x
1,9	x	x			x		
1,5,9	x	x					
2,6,10	x			x			
⋮							
1,2,5,6	x						x
⋮							
1,3,5,7,9,11		x			x		
⋮							

UL = UPPER LONG ARM
LL = LOWER LONG ARM
US = UPPER SHORT ARM
LS = LOWER --

Fig 6

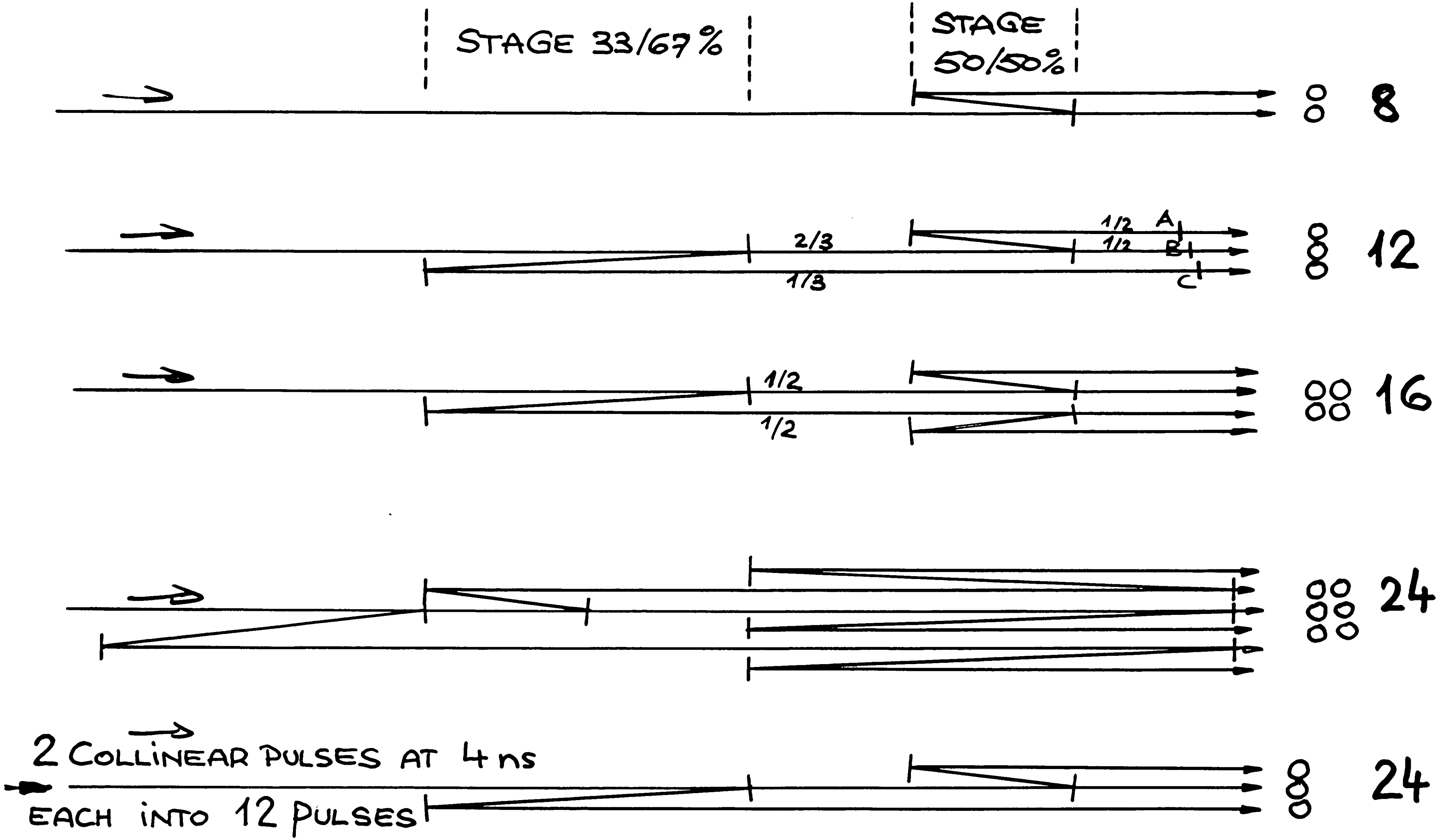

STAGE 33/67%
STAGE 50/50%
8
2/3
1/3
1/2
1/2
A
B
C
12
1/2
1/2
16
24
2 COLLINEAR PULSES AT 4 ns
EACH INTO 12 PULSES
24

Fig 7

Single bunch phase
scan, Laser spot size
on PC small (≈ 2mm Ø ?)

Childs law of space charge limit
for Cathodes:

$$i \leq 10\left[\frac{kA}{cm^2}\right] E\left[\frac{MV}{cm}\right]$$

$$i = \frac{3.2\,nC}{12\,ps\;\pi \cdot 0.07\,cm^2} = 8.5\,\frac{kA}{cm^2}$$

$$E = 7\,\frac{MeV}{cm}$$

Max UMA385 = 3.2 nC

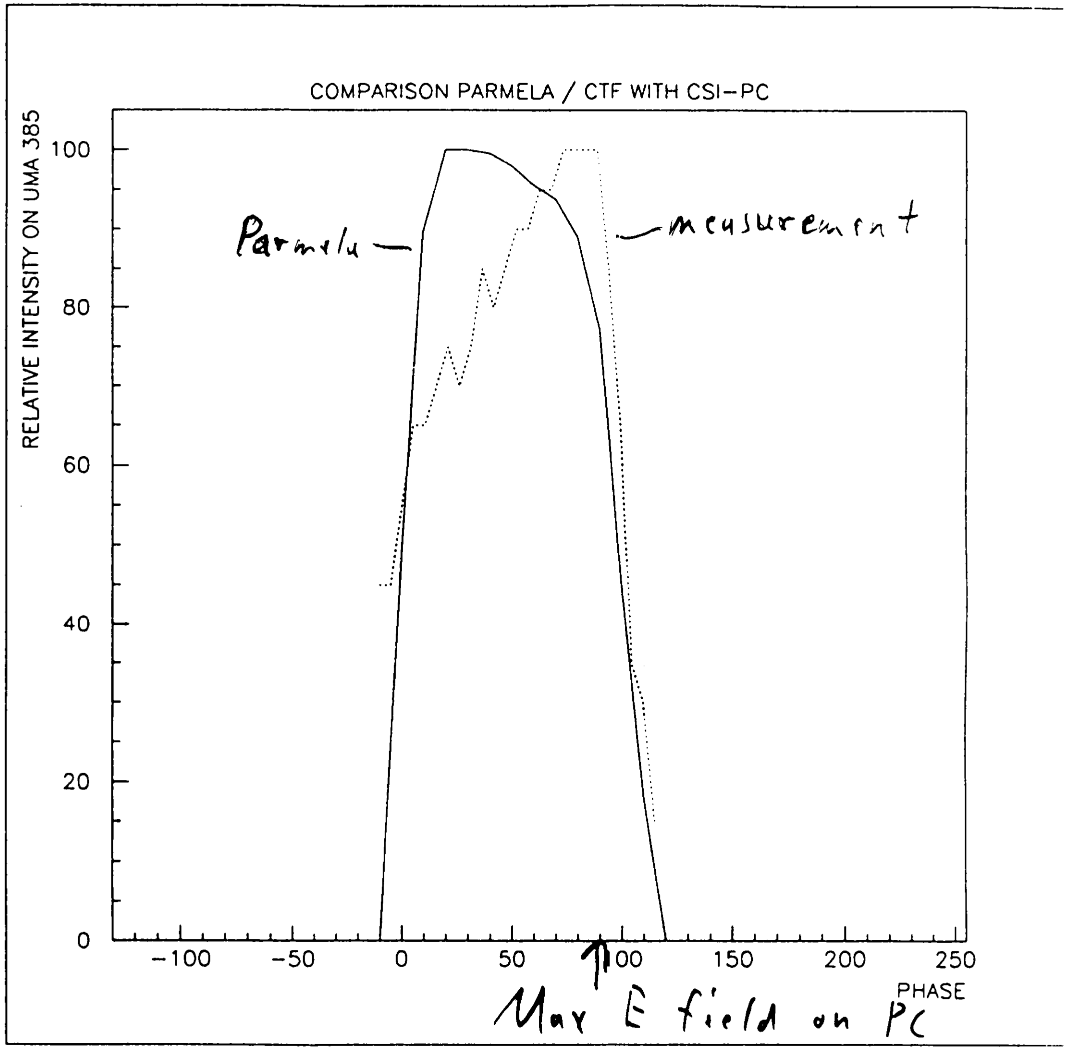


Fig 8

Max(UMA385) = 93.3 nC

W = 76.5 μJ

Max(UMA385) = 5.5 nC

W = 1.8 μJ

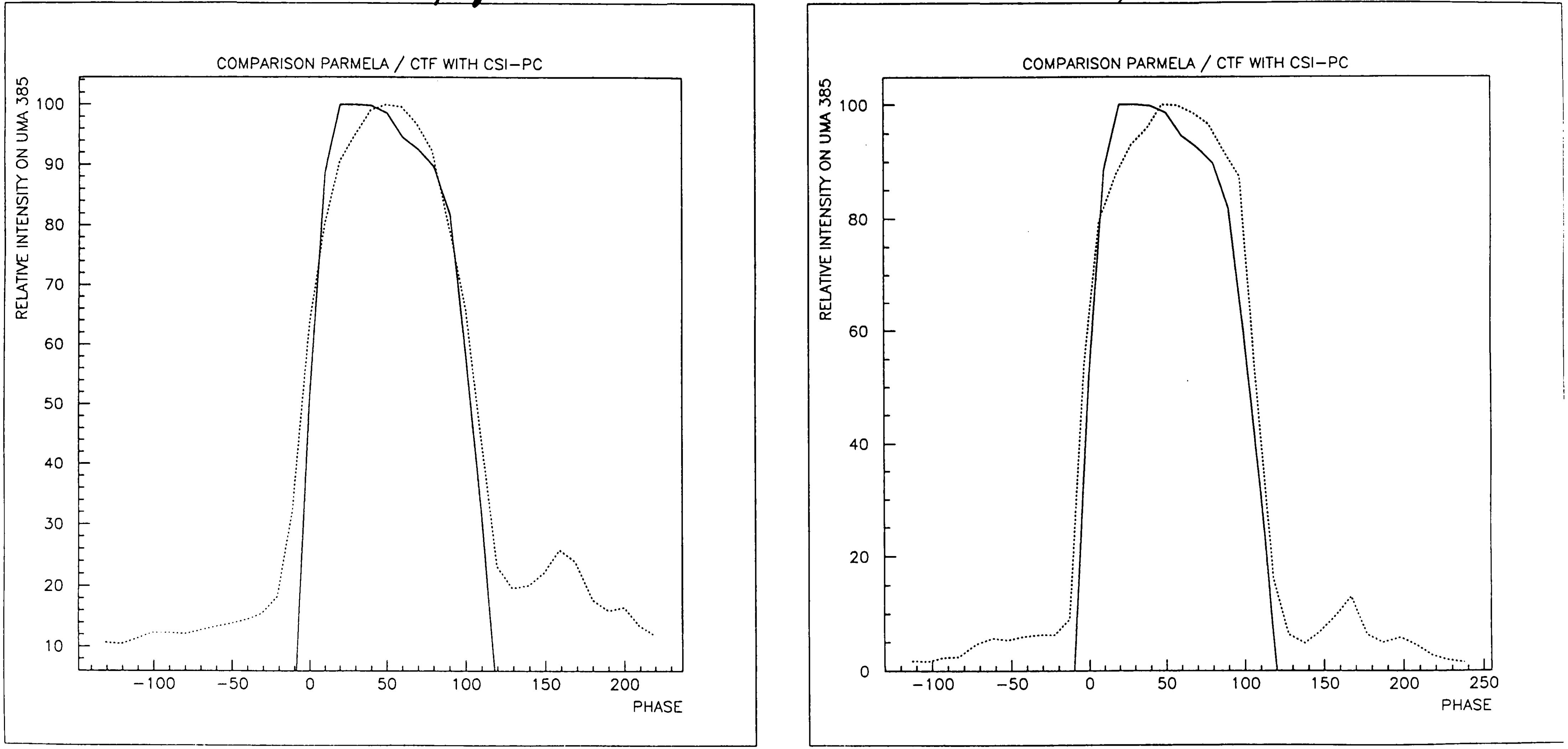


Fig 9.

Problem with q ~ Epc seems to have vanished

Remember: Steve has increased spotsize to ⌀ 8mm

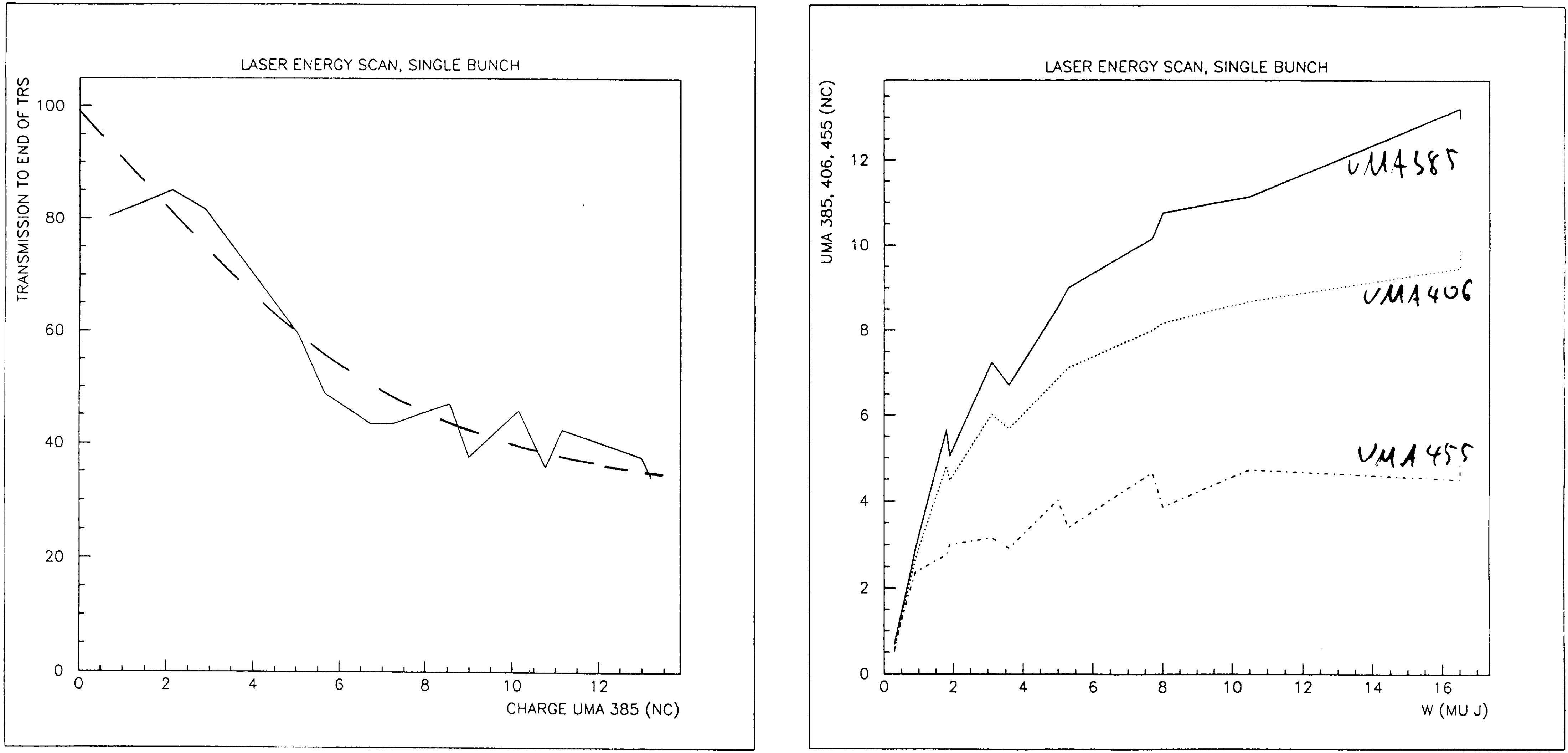

LASER ENERGY SCAN, SINGLE BUNCH
TRANSMISSION TO END OF TRS
100
80
60
40
20
0
0
2
4
6
8
10
12
CHARGE UMA 385 (NC)
LASER ENERGY SCAN, SINGLE BUNCH
UMA 385, 406, 455 (NC)
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
W (MU J)
UMA 385
UMA 406
UMA 455

Fig 10

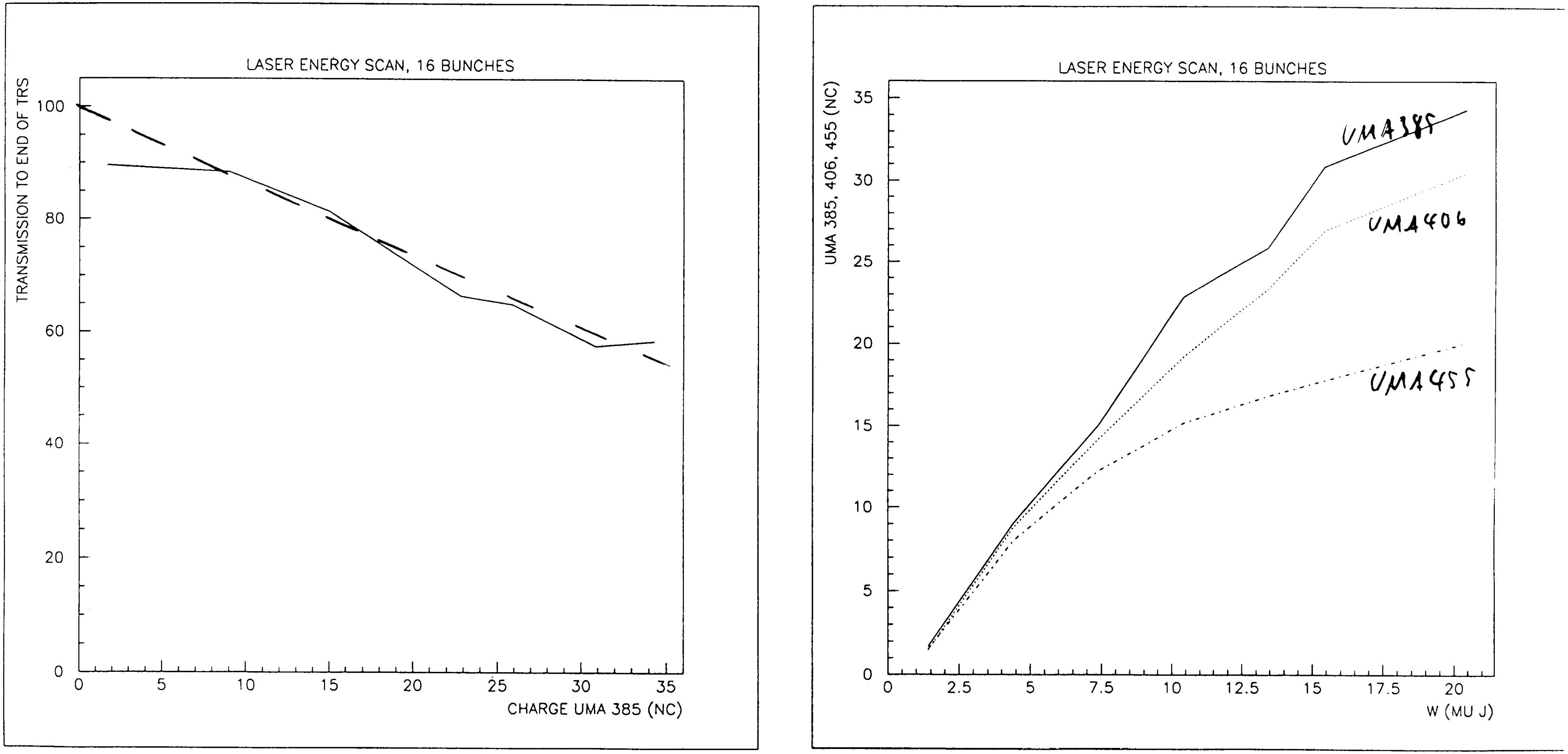
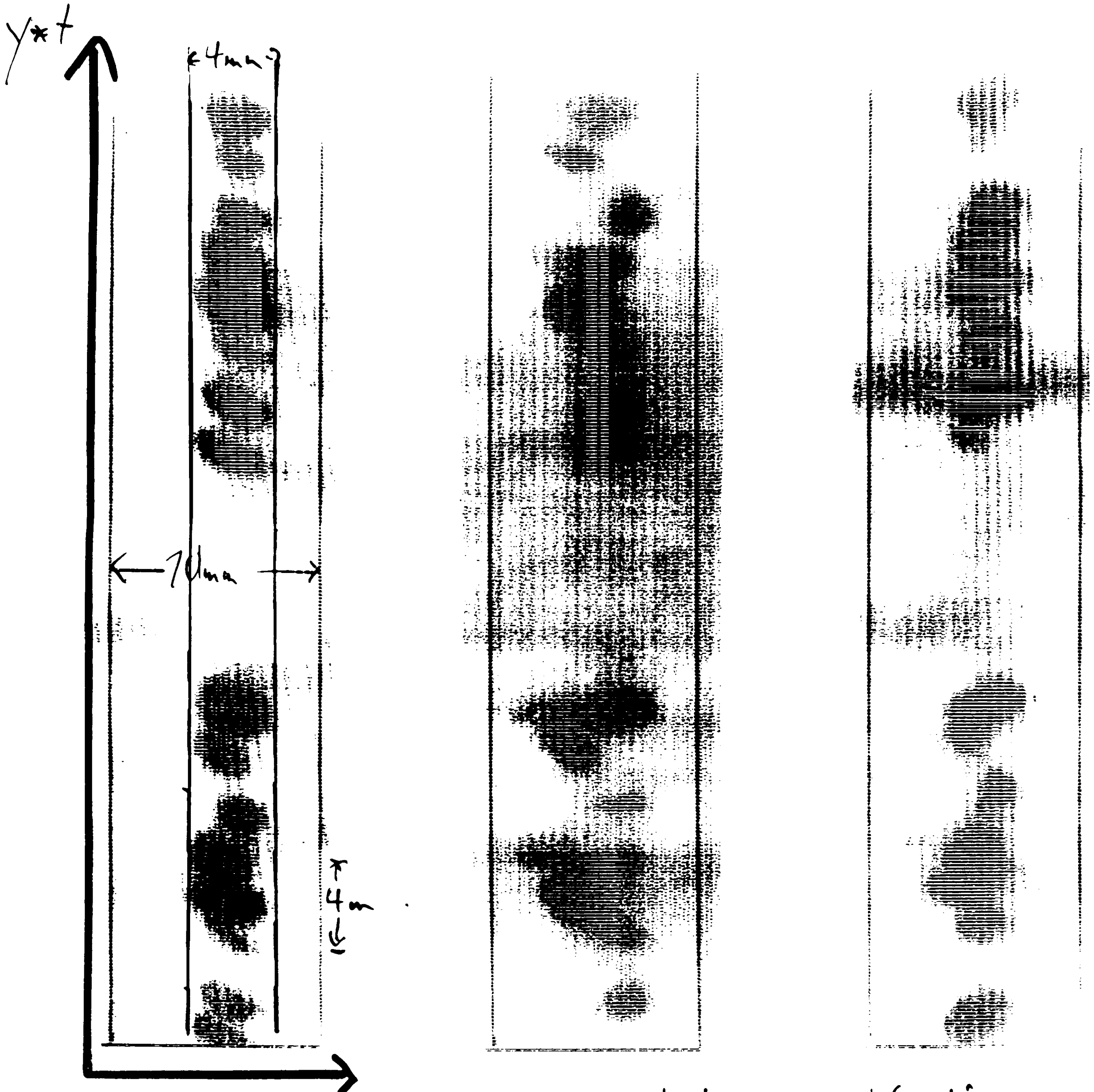

LASER ENERGY SCAN, 16 BUNCHES
TRANSMISSION TO END OF TRS
100
80
60
40
20
0
0
5
10
15
20
25
30
35
CHARGE UMA 385 (NC)
LASER ENERGY SCAN, 16 BUNCHES
UMA 385, 406, 455 (NC)
35
30
25
20
15
10
5
0
0
2.5
5
7.5
10
12.5
15
17.5
20
W (MU J)
UMA385
UMA406
UMA455

Fig 11



Beam aligned on UMA406

Horizontal missteering

Vertical missteering

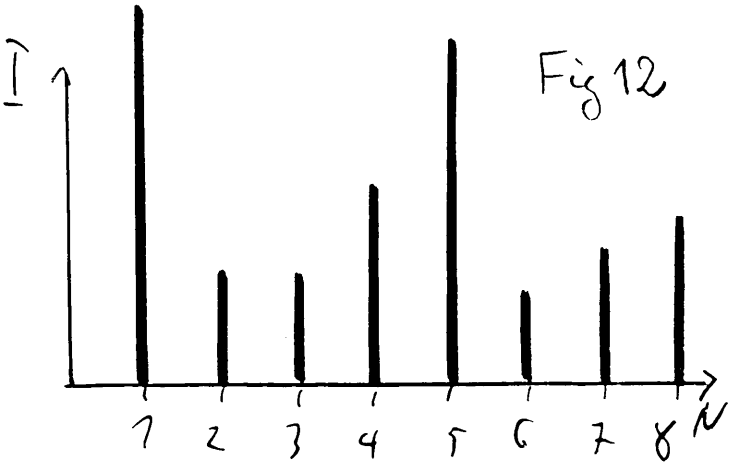


Fig 12

Different spotsize is due to unequal bunch intensities, caused by the train generator

* trying to improve transmission through TRS

→ difficult

```
     |Average:   (     )                 |
nmeas  10 HOR(mm) VER(mm) Ch.(E8)
K.UHA170    27.6     0.5   25.4          |
K.UHA235   111.1   111.1    0.0          |
K.UHA385    -1.0     1.2-1950.1          |
K.UHA406    -1.0     0.1-1745.9          |
K.UHA455    -1.0    -0.7-1025.4          |
 Thu May 27 21:42:08

Thu May 27 22:00:31 |
      |Average:   (     )
nmeas  10 HOR(mm) VER(mm) Ch.(E8
K.UHA170    20.8     0.5   25.4
K.UHA235   111.1   111.1    0.0
K.UHA385    -2.0     0.7-2003.1
K.UHA406    -0.6     0.6-1837.2
K.UHA455    -0.7    -0.2-1178.3
     |Average:   (     )                 |
nmeas  10 HOR(mm) VER(mm) Ch.(E8)
K.UHA170    20.8     0.5   25.4          |
K.UHA235   111.1   111.1    0.0          |
K.UHA385    -1.0     1.1-2140.8          |
K.UHA406    -1.0     0.2-1901.7          |
K.UHA455    -0.9    -0.4-1252.2          |
```

30,6 nC upstream TRS

not better than that

20,1 nC downstream TRS

$$\hat{P} \approx 30{,}74 \cdot q^2 \cdot F^2 \cdot \underline{0{,}92}$$

← Reduction due to splitting in 2 trains

$30{,}6\,nC \rightarrow F = 0{,}59$

$20{,}1\,nC \rightarrow F = \underline{0{,}90}$

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 27-MAY-93 time: 21: 48: 40

30 GHz Signal (downconverted)

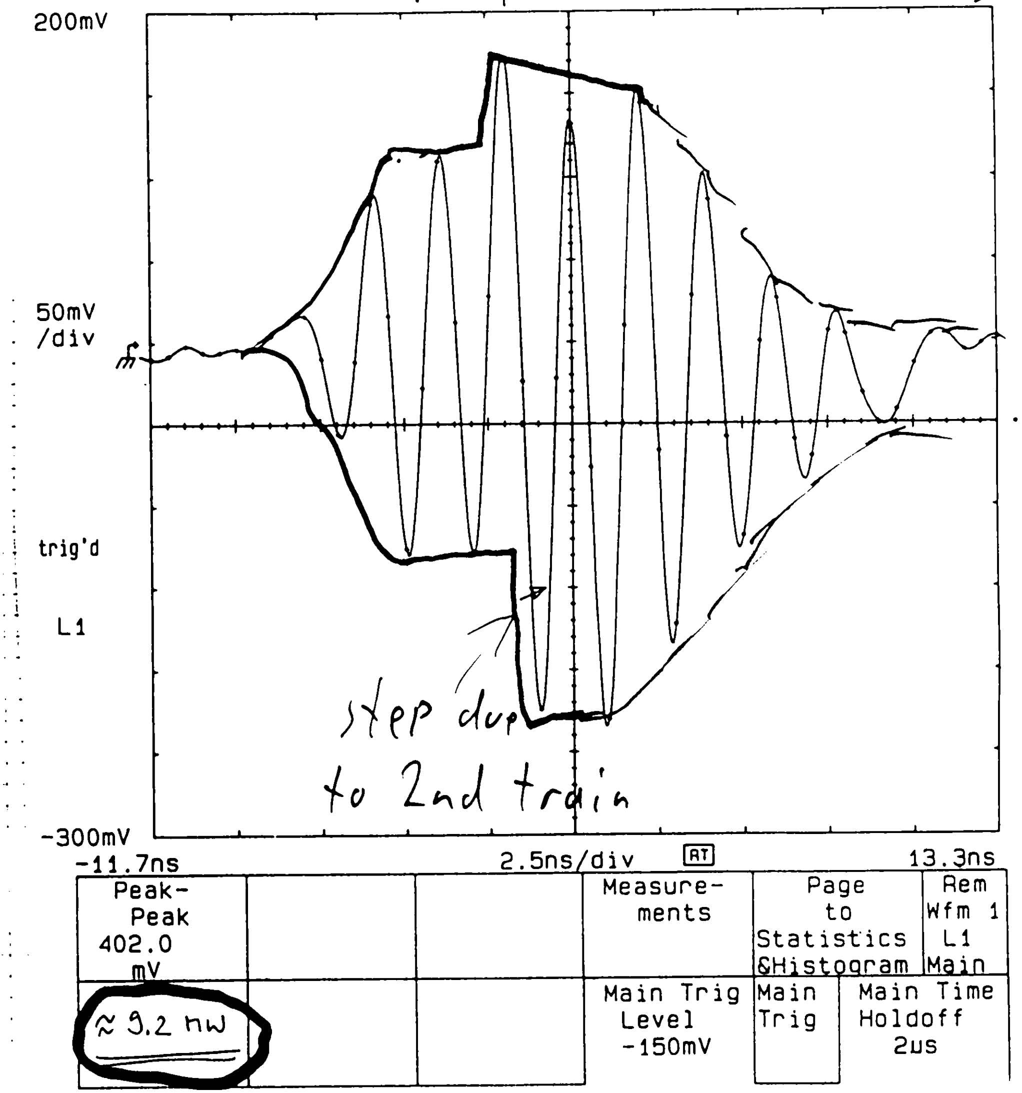
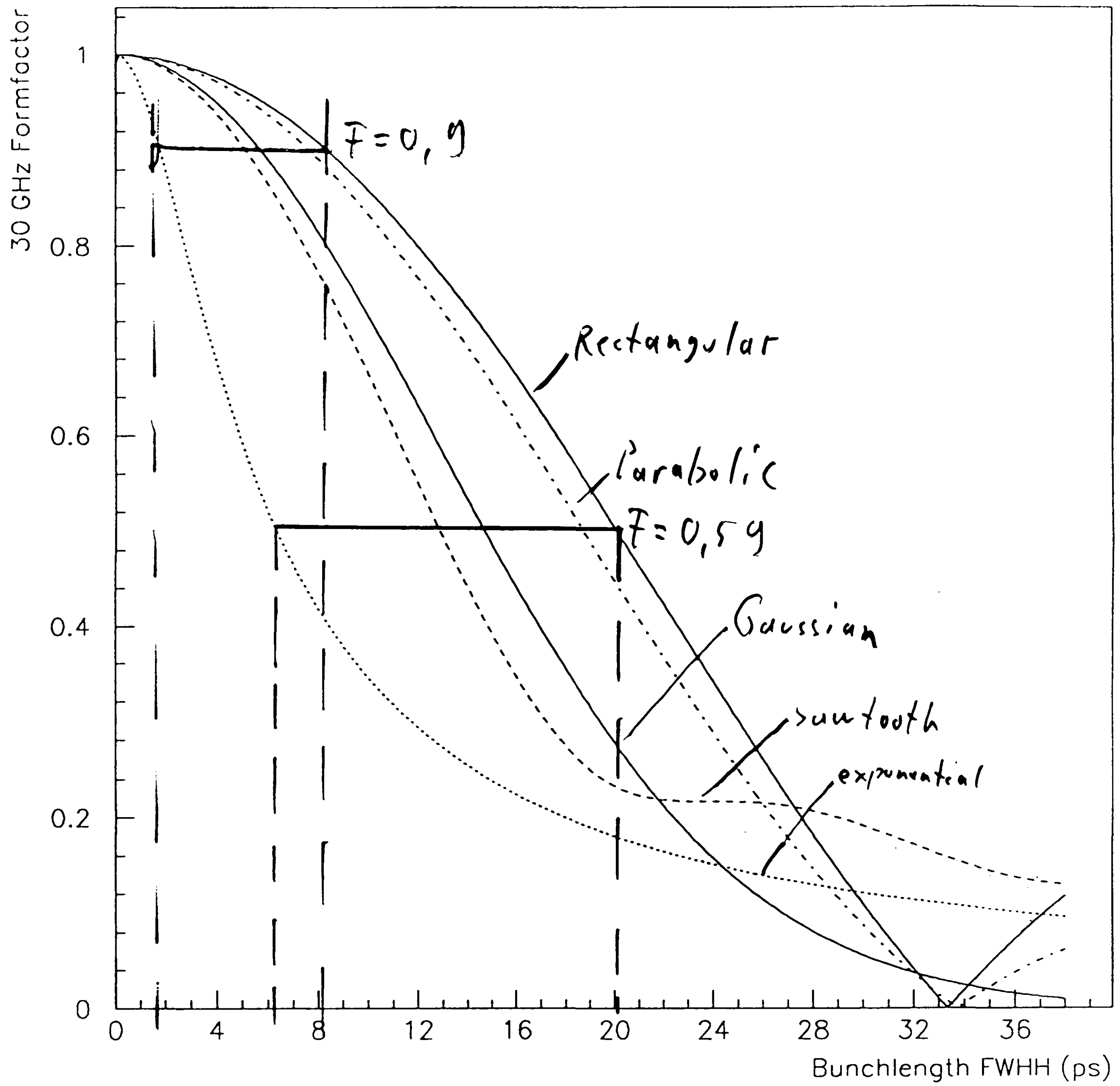


Fig 13



→ Bunchlength FWHH 1.5-8 ps

→ or 6-20ps

Streak camera measures 12 ps for laser pulse, but 19ps for e^- beam

PARMELA predicts ≃ 5ps e^- bunch length for 12ps laser pulse

Fig 14.

Best charge obtained so far

	UMA 385	UMA 406	UMA 455	
single bunch	14 (11)	9 (7)	5 (4)	← '92 best values.
8 bunches	21	18	12	'92 best values
16 bunches	34	30	20	

$$\hat{P}_{30\,GHz} \quad \underset{'92}{2{,}7\,MW} \longrightarrow 10\,MW$$

From charge alone one would expect

$$\hat{P} = 2{,}7\,MW\left(\frac{20}{12}\right)^2 \cdot \underbrace{0{,}92}_{\text{reduction due to train spacing}} = 6{,}9\,MW \quad ?$$

Fig 15